App. F. IX-1

Previous References. (1941-2 War) **File No.** 28-41

Serial Nos. 1-2.

Later References.

25

GENERAL AND REVENUE SECRETARIAT.

Serial Nos. Two only.

Part B for July 1942.

SUBJECT.

Pamphlets re. ARP in factories

Chaman Lal

W. 28-41-1 Col 14.

98/W

THE OFFICE OF THE HON'BLE THE RESIDENT IN MYSORE.

P.O. War

Dated Bangalore, 2nd July 1942.

No. F.3(18)-42/W. (Enc 12 copies each)

Twelve copies each of the undermentioned papers are forwarded with compliments to the Chief Secretary to the Government of His Highness the Maharaja of Mysore, Bangalore, for information and favour of distribution to classified factories in the Mysore State to whom the "Summary of A.R.P. Applied to factories" has been supplied.

By order, etc.,

W. K. Aman Asst

for SECRETARY TO THE RESIDENT.

CSN

(1) Appendix II to "A Summary of A.R.P. Applied to Factories."

(2) Notes on A.R.P. Planning and construction for new factories or extensions.

Serial No.

11 copies of the Summary of A.R.P Appeals to Zaibatris have been previously distributed (Green Circular file)
11 copies each of the Express News may be sent to the D.C.P. for distribution to Sub-Units & Posts

NOTE—Contn. Sheet.

WD 04155—GPB—55,000—23-10-41

B/2

Jms 153/W & 10/Gs. 42/4 tel 158

Appendix F G—1]

SUBJECT..... Summary of A.R.P. Precautions

.....

.....

Section

File No.

Serial No.

Diary No. of letter replied to.....

No. 153/W.

To W.28-b-2

The D. G. A. P

General and Revenue Secretariat

( )

the *19*

Sir, I am directed to forward herewith 11 copies each of the pamphlets noted in the margin for distribution to the classes of factories in the States to whom the "Summary of A.R.P. Applied to Factories" has been sent for this Department's comments.

Date of issue..... 10.7.42

Signed by ..... Mr. S.K.V.

(for Secretary to the P.W.D.)

List of enclosures.....

Copied by .....

Examined by .....

for Chief Secretary

D L. 64 B
4,500

GOVERNMENT OF INDIA

DEPARTMENT OF LABOUR

APPENDIX II

TO

A SUMMARY OF

AIR RAID PRECAUTIONS

APPLIED TO FACTORIES

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI.
1942.

Price annas 2 or 3d.

This memorandum has been written in the light of information received from the Ministry of Home Security and Ministry of Supply, United Kingdom.

20th April 1942.

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APPENDIX II.

Structural Measures for Limiting and Preventing Fires in Roofs.

Special consideration must be given to roof-lights and similar roof openings. All such openings should, where practicable, be made impenetrable. This can be done by covering them with timber joists and boarding and a layer of 2″ concrete paving flags, alternatively a $1\frac{1}{4}$″ layer of concrete on 20 gauge corrugated iron, $1\frac{3}{4}$″ on 24 gauge corrugated iron, or $2\frac{1}{2}$″ on 26 gauge corrugated iron may be used.

The following notes describe measures that should be taken to facilitate fire-fighting operations and to check the spread of fire along existing roofs which consist wholly or in part of timber or other combustible materials.

The Japanese are using very much heavier types of incendiary bombs weighing as much as 60 to 100 kilos, but even with this method of attack, the precautions and measures suggested to facilitate fire-fighting operations and to check the spread of fires along roofs hold good.

The incendiary material in the common type of phosphorus incendiary bomb consists of numerous discs of rubber impregnated with phosphorus. On explosion the incendiary pellets are thrown over a wide area, and it is very likely that some of these may find their way to and lodge themselves in the roofs of any buildings in the vicinity of the explosion. If left there unattended they would start a fire. Further, access to roofs is of invaluable assistance in firefighting, whether the fire has spread to the roof from a conflagration inside the building, or has been initiated in the roof itself by incendiary pellets lodged there.

These measures may conveniently be considered under the following heads :—

(i) Access to roofs,

(ii) Fire Stops.

Access to Roof :

(i) In order that fire prevention personnel may reach roofs rapidly, ladders and catwalks should be constructed. Flat roofs are generally so constructed as to resist penetration by light incendiary bombs, and on these it is only necessary to ensure that all levels can be easily reached. On sloping roofs the need for catwalks and catladders will vary considerably according to the design and construction of the roof. In the case of roofs covered with tiles, corrugated iron sheets and similar materials which are classed as non-resistant to penetration, the great majority of incendiary bombs will penetrate to the ceiling or floor below, and, in such cases, measures for attacking the bombs inside the building are of considerably more importance than the preventive measures required on the outer surface of the roof. Sloping resistant roofs, on the other hand, are likely to deflect incendiary bombs into the gutters or over the eaves. The need for ready means of access is, of course, most urgent where the roof is of a combustible nature.

(ii) *From ground level to roof.*—Where no staircases or external fire-escapes already exist, some other measures of rapid and safe access from ground level to roof must be provided. Sloping ladders are preferable to vertical ladders, as a man burdened with a stirrup pump or bucket of water cannot scale a vertical ladder in many cases.

(a) *For single storey buildings* up to 20′ in height, light, single-length portable wooden ladders should be provided at each end of the building. A scale of not less than one for every five valleys is suggested for guidance.

(b) *For single storey buildings* over 20′ in height, stair-cases or fixed sloping ladders should be erected at each end of the building on the scale of not less than one for every five valleys. These should be arranged in flights between landings constructed as cantilevers from the walls or supported from the ground.

(c) *In multi-storey buildings*, access to the roof should be provided by means of a fixed ladder from the top storey through a trap door or dormer window openings. Where no such openings

already exist they should be constructed, as required, as near as possible to a gutter or horizontal roof-walk. In large buildings it may be necessary to provide more than one such means of access. It is also essential that, in both single-storey and multi-storey buildings, there should be an alternative means of escape for use in the event of a fire becoming uncontrollable. Where there is only one means of access to a roof, the escape ladder must be erected at the opposite end. For this purpose, ladders fixed vertically to the wall at the end of a valley gutter will serve the purpose, but they must be so sited that they do not pass in front of windows or other wall openings.

(iii) *Roof-Walks.*—The general aim is to provide means of rapid movement along or across a roof, and where possible, to bring dangerous parts of the roof within reach of a stirrup hand-pump.

On most factory roofs, the valley gutters, suitably boarded, will serve as horizontal walks, but where none exist, *i.e.*, on single roofs with a normal eaves overhang, horizontal walks may require to be constructed, either bracketed from the roof slope, or cantilevered from the walls, just below eaves level. Horizontal walks should be 18 inches minimum width, of duckboards $1\frac{1}{4}$ inches thick, and handrails must be provided wherever there is a risk of falling off, *e.g.*, on walks at the edges of eaves, or bracketed from roof slopes. Access from valley to valley should be by means of cat-ladders fixed to the slope of the roof about 15 feet from each end, or alternatively by horizontal walks at the gable ends bracketed to the roof slope or to the wall at eaves level. On very large roofs it may be considered necessary to fix additional cat-ladders to adjacent valleys at intermediate points, but this will depend on the degree of fire risk. Movable ladders should not be used for the purpose of providing access from valley to valley.

The cat-ladders should be constructed of two $9'' \times 1\frac{1}{2}''$ boards fixed side by side, with steps of $2'' \times 2''$ battens nailed to them, and one handrail must be provided.

In certain cases of exceptionally high fire risk, it may be necessary to provide the most rapid possible means of crossing the roof in a direction at right angles to the valleys. This can be done by means of catwalks bridged across the valleys on steel or timber frames. Such gangways need to be provided with two handrails, and ladders to connect them to the horizontal walks in the valley gutters will also be required. In view of the considerable expenditure of material and labour involved in this design it should only be adopted in special circumstances.

On roofs where the distance up the slope exceeds 15 feet from the valley, the upper portions can be brought within reach of a stirrup hand-pump by means of a light movable ladder, provided that the roof construction is substantial enough to carry the weight of the operator. In rare cases where, owing to flimsy construction or the presence of large areas of glazing, the roof will not safely take this extra weight, it may be necessary to construct an additional horizontal catwalk, either along the ridge or bracketed from the roof slope. Here again, the degree of fire risk will determine whether expenditure on this extra measure is justified.

The top and bottom of ladders and cat-ladders (to a distance of 3′) should be painted white or yellow, but *not* the whole of the ladder. Similarly, dangerous spots in catwalks may be marked by circles in white or yellow paint not exceeding 20 inches in diameter, but the whole length of such walks must not be painted.

(iv) *Equipment to be kept on roof.*—At least two buckets of water and one bucket of sand should be placed at each end of every valley or parapet gutter, or in such positions as may be most convenient, *e.g.*, at the top or foot of cat-ladders.

Fire Stops:

The "fire stop", shown diagramatically in the figure given below, is a simple structural device that can be erected to check the spread of fires along existing roofs which consist wholly or in part of timber or other combustible materials. A strip of the roof extending across the whole of the width of the span is closely sheathed with light metal sheet or other suitable

material to prevent access of air to the timber. Vertical flame screens are added above and below the roof, extending along the centre of the sheathed strip.

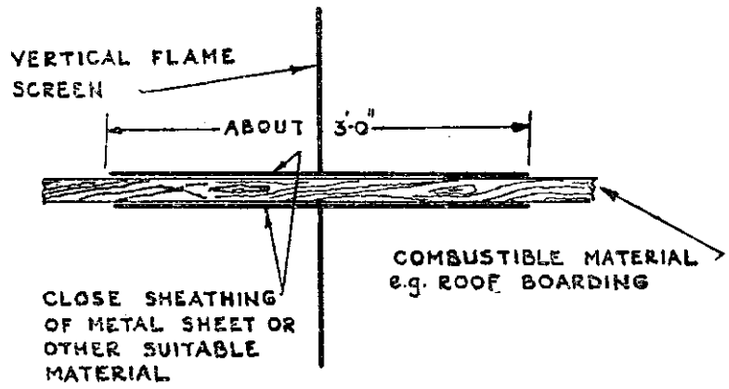

VERTICAL FLAME SCREEN
ABOUT 3'-0"
COMBUSTIBLE MATERIAL e.g. ROOF BOARDING
CLOSE SHEATHING OF METAL SHEET OR OTHER SUITABLE MATERIAL

DIAGRAM SHOWING GENERAL DESIGN OF FIRE STOPS

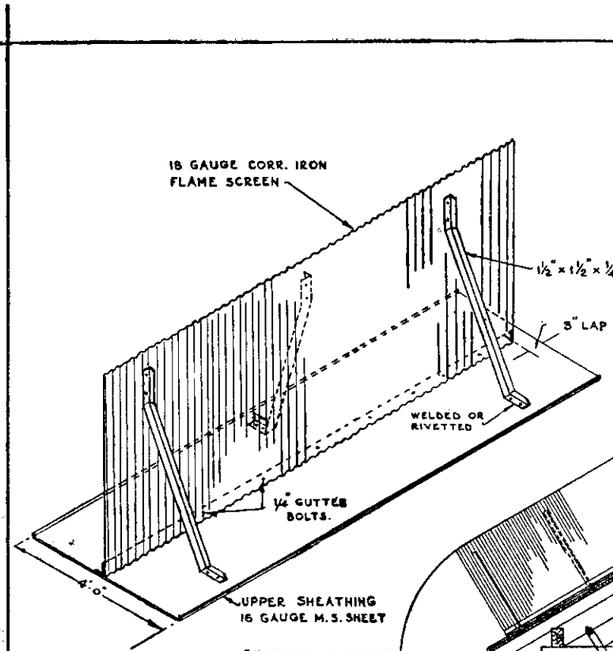
It is to be noted that the primary object of the device is to delay the spread of fire along timber roofs and to provide rallying points for fire fighters where active measures would be particularly effective. In certain circumstances, for instance where the fire is not too intense, the stops might prevent the spread of fire completely.

The devices could not be expected to be effective in a building stocked with large quantities of combustible materials, which, burning inside the building, would in effect "Short circuit" any roof "fire stop", but there is a large class of important buildings in which these conditions do not obtain. For instance, in buildings which contain no combustible goods within 20' of the roof timbers the fire parties or fire brigade would probably have a good chance of bringing under control a fire on the floor before it could pass under the "fire stop" in the roof and ignite the roof beyond the "fire stop".

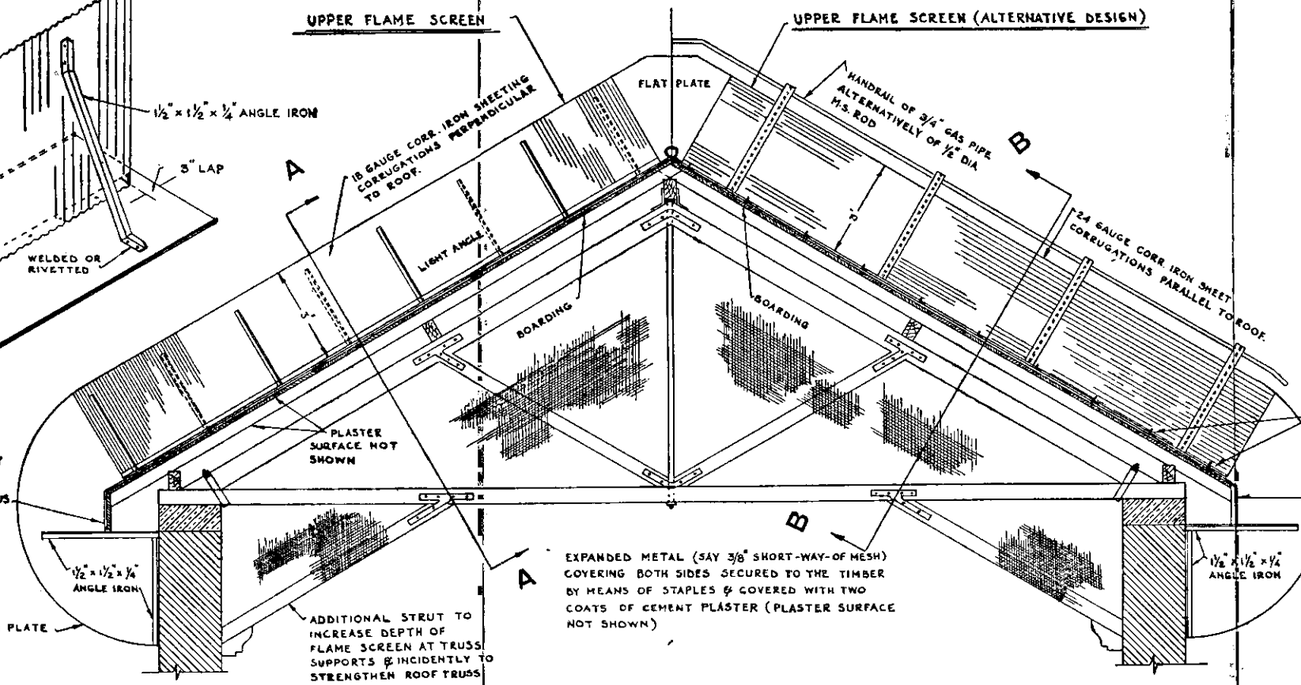
Fire Stops should be provided at frequent intervals along the roof. The positions of the Fire Stops in each individual case should be selected after careful consideration of the many factors involved. These would include the importance of the building covered by the roof, either from the point of view of damage to contents or effect on output, the need for reducing the hazard to neighbouring buildings, and structural considerations such as the need for protecting the bays containing wind bracing.

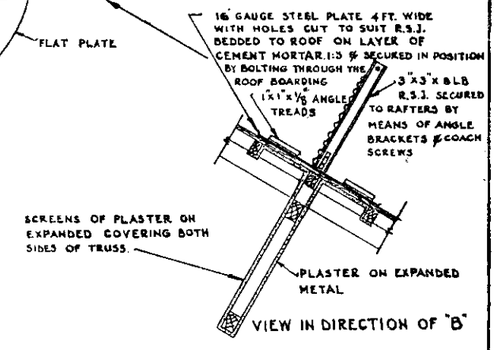
For the Fire Stop to be effective, the upper flame screen should not be less than 2', preferably 3', high. On bituminous felt covered roofs the sheathing should be laid directly on top of the bituminous felt covering. Where the roof covering consists of tiles, it is suggested that the tiles should first be removed and then either bedded in cement mortar on the roof boarding before the roof sheathing is applied, or else the sheathing bedded in mortar direct on the boarding. The sheathing is secured in position by bolting through the roof boarding. The upper flame screen should be continued around the eaves. The upper sheathing can consist of 16 gauge mild steel plate, and the flame screen of corrugated iron set up on the centre line of the sheathing, to which it is attached by means of riveted or spot welded iron brackets or supports.

The lower sheathing should be as wide as possible. It should at least extend to, and cover, the rafters adjacent to the one on which the "fire stop" is erected. The sheathing can consist of light gauge metal or of plaster on metal laths. When light gauge metal is used, it must be shaped to fit closely to the boarding and rafters and can be secured by means of bolts through the roof boarding. The inside of the sheets immediately before erection should be coated with fire-retardant sodium silicate paint.


18 GAUGE CORR. IRON FLAME SCREEN
1½" x 1½" x ¼" ANGLE IRON
3" LAP
WELDED OR RIVETTED
¼" CUTTER BOLTS.
4'-0"
UPPER SHEATHING 16 GAUGE M.S. SHEET
SHEATHING CONTINOUS OVER EAVES BOARD
1½" x 1½" x ¼" ANGLE IRON STAY.
PLASTER ON EXPANDED METAL
SCREENS OF PLASTER ON EXPANDED COVERING BOTH SIDES OF TRUSS.
16 GAUGE STEEL PLATE 4" WIDE BEDDED ON BOARD WITH CEMENT MORTAR 1:3 & SECURED IN POSITION BY BOLTING THROUGH THE ROOF BOARDING

VIEW IN DIRECTION OF "A"


UPPER FLAME SCREEN
UPPER FLAME SCREEN (ALTERNATIVE DESIGN)
18 GAUGE CORR. IRON SHEETING CORRUGATIONS PERPENDICULAR TO ROOF.
FLAT PLATE
HANDRAIL OF 3/4" GAS PIPE ALTERNATIVELY OF 1/2" DIA M.S. ROD
24 GAUGE CORR IRON SHEET CORRUGATIONS PARALLEL TO ROOF.
LIGHT ANGLE
BOARDING
PLASTER SURFACE NOT SHOWN
1"x1"x1/8" ANGLE TREADS RIVETTED OR SPOT WELDED AT 2'-0" CENTRES TO FORM "CAT WALK"
SHEATHING CONTINOUS OVER EAVES BOARD
1½" x 1½" x ¼" ANGLE IRON
FLAT PLATE
ADDITIONAL STRUT TO INCREASE DEPTH OF FLAME SCREEN AT TRUSS SUPPORTS & INCIDENTLY TO STRENGTHEN ROOF TRUSS
EXPANDED METAL (SAY 3/8" SHORT-WAY-OF MESH) COVERING BOTH SIDES SECURED TO THE TIMBER BY MEANS OF STAPLES & COVERED WITH TWO COATS OF CEMENT PLASTER (PLASTER SURFACE NOT SHOWN)
A
B


16 GAUGE STEEL PLATE 4 FT. WIDE WITH HOLES CUT TO SUIT R.S.J. BEDDED TO ROOF ON LAYER OF CEMENT MORTAR 1:3 & SECURED IN POSITION BY BOLTING THROUGH THE ROOF BOARDING
3"x3"x 8LB R.S.J. SECURED TO RAFTERS BY MEANS OF ANGLE BRACKETS & COACH SCREWS
(1"x1"x1/8" ANGLE) TREADS
SCREENS OF PLASTER ON EXPANDED COVERING BOTH SIDES OF TRUSS.
PLASTER ON EXPANDED METAL

VIEW IN DIRECTION OF "B"

NOTE :-

1. FIRE STOPS SHOULD BE PROVIDED AT INTERVALS ALONG THE ROOF. THE POSITIONS OF THE FIRE STOPS IN EACH INDIVIDUAL CASE SHOULD BE SELECTED AFTER CAREFUL CONSIDERATION OF THE MANY FACTORS INVOLVED. THESE WOULD INCLUDE THE IMPORTANCE OF THE BUILDING COVERED BY THE ROOF, EITHER FROM THE POINT OF VIEW OF DAMAGE TO CONTENTS OR EFFECT ON OUTPUT, THE NEED FOR REDUCING THE HAZARD TO NEIGHBOURING BUILDINGS & STRUCTURAL CONSIDERATIONS.

FOR PURPOSES OF ERECTION THE TILES ARE FIRST REMOVED FROM THE ROOF BOARDING, AND THE UPPER SHEATHING IS BEDDED DOWN ON TO THE BOARDING IN CEMENT MORTAR 1:3 & SECURED IN POSITION BY BOLTING THROUGH THE ROOF BOARDING. THE TILES ARE REPLACED, OVERLAPPING SLIGHTLY THE SIDES OF THE SHEATHING WHICH ARE TURNED UP TO PREVENT INGRESS OF WATER. THE LAYER OF CEMENT PLASTER UNDER THE SHEATHING SHOULD BE ¾" TO 1" THICK

THE SPACING OF THE STANCHIONS & BRACKETS SUPPORTING THE UPPER FLAME SCREEN MUST BE CHOSEN TO SUIT EACH PARTICULAR TYPE & SIZE OF ROOF. THEY SHOULD BE SUFFICIENTLY CLOSELY SPACED TO GIVE ADEQUATE SUPPORT TO THE FLAME SCREEN AGAINST WIND PRESSURE.

SCALE 3/8" = 1'

FIRE STOP FOR TIMBER ROOF

SCALE: 3/8" = 1 FT APPROX.

DRG. NO G.A. 5.

DATE 6-4-42

CHIEF ADVISER, FACTORY A.R.P.

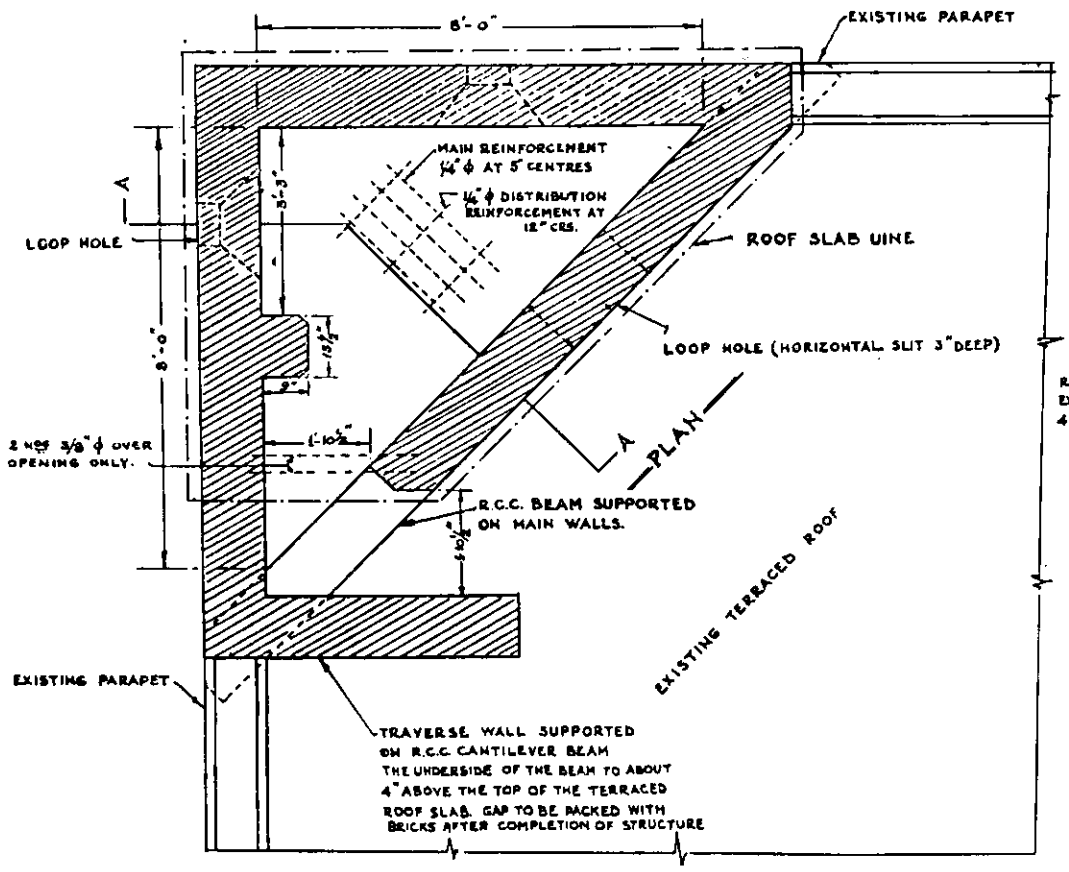
The lower flame screen consists of plaster on metal laths, 3/8″ short-way-of-mesh. The laths are secured to each side of the rafter and extended downwards to the level of the underside of the tie or to the level to which the screen is proposed to be provided. The lower flame screen should be as deep as possible; the ideal is to extend it to the floor below. It should in any case extend to the level of the underside of the wall plates. In large roofs, where from considerations of expense and convenience, it is not possible to put these recommendations into effect, it is suggested that the screen should be made as deep as possible (3′ at the very least) and that its lower edge should be parallel to the pitch of the roof. Any exposed timber members immediately below the screen should then be protected by a covering of plaster on metal laths or other suitable material.

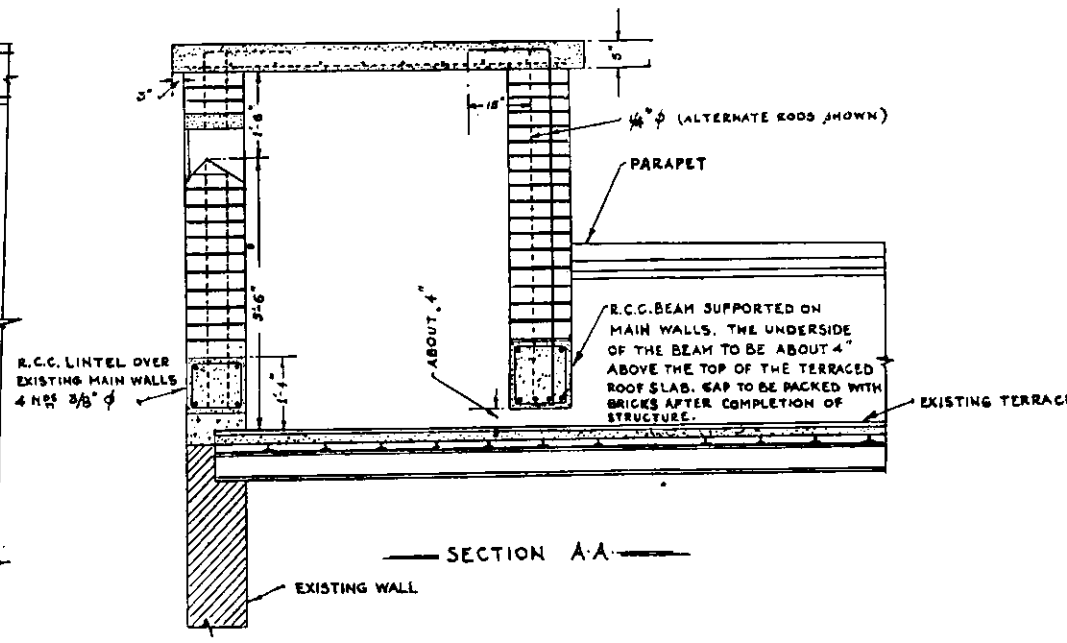
All exposed timber on the underside of the roof should be coated with a fire retarding paint. Timber so coated is more difficult to ignite and it takes a more intense fire to set it alight than would be the case with untreated timber.

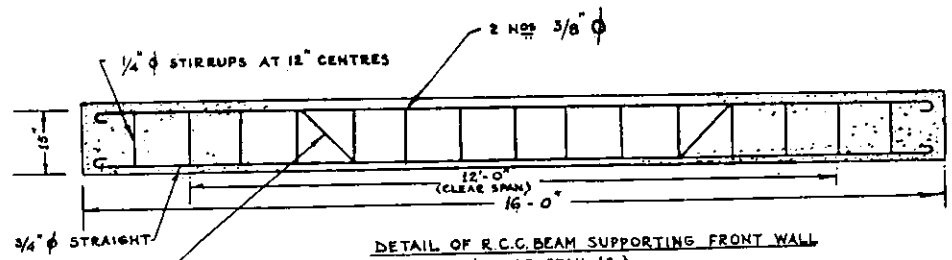
Fire Watcher Post:

Considerable difficulty is experienced in providing protected accommodation for fire-watchers on roof tops. The terraced roof or slab is generally designed for a small superimposed load and it is not feasible to erect the usual type of fire watcher posts on such roofs.

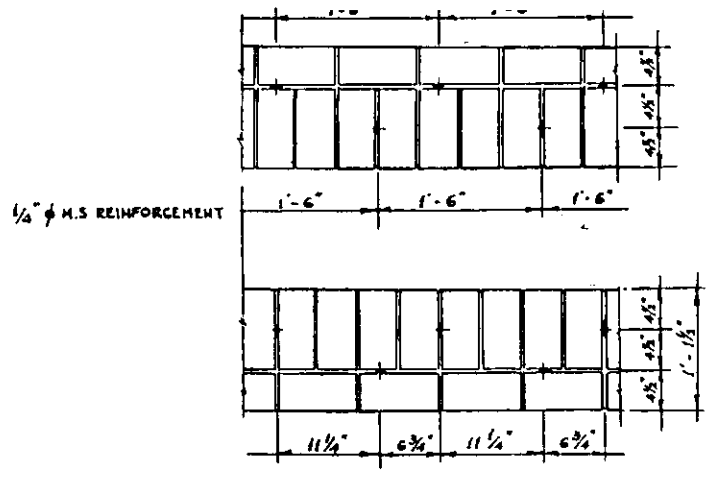
Drawing No. CA4 shows a design for a "Fire Watcher" Post. The design is suitable for use on terraced or flat roofs which are not strong enough or which cannot be conveniently strengthened or propped to take the load of a heavy structure. In the design shown the full load of the structure is carried by the main walls. The underside of the main beam over which the front wall is erected and the underside of the cantilever beam supporting the baffle wall should be about 4 inches above the top of the roof slab, so as not to transmit any stresses to the roof slab. The gaps should be packed with bricks when the structure is completed to prevent possible entrance of splinters.


8'-0"
EXISTING PARAPET
MAIN REINFORCEMENT ¼"ϕ AT 5" CENTRES
¼"ϕ DISTRIBUTION REINFORCEMENT AT 12" CRS.
ROOF SLAB LINE
LOOP HOLE
LOOP HOLE (HORIZONTAL SLIT 3"DEEP)
A
PLAN
2 Nos ⅜"ϕ OVER OPENING ONLY.
R.C.C. BEAM SUPPORTED ON MAIN WALLS.
EXISTING TERRACED ROOF
EXISTING PARAPET
TRAVERSE WALL SUPPORTED ON R.C.C. CANTILEVER BEAM THE UNDERSIDE OF THE BEAM TO ABOUT 4" ABOVE THE TOP OF THE TERRACED ROOF SLAB. GAP TO BE PACKED WITH BRICKS AFTER COMPLETION OF STRUCTURE

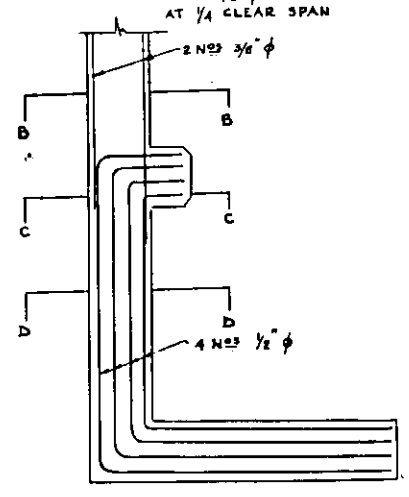

¼"ϕ (ALTERNATE RODS SHOWN)
PARAPET
R.C.C. BEAM SUPPORTED ON MAIN WALLS. THE UNDERSIDE OF THE BEAM TO BE ABOUT 4" ABOVE THE TOP OF THE TERRACED ROOF SLAB. GAP TO BE PACKED WITH BRICKS AFTER COMPLETION OF STRUCTURE.
R.C.C. LINTEL OVER EXISTING MAIN WALLS 4 Nos ⅜"ϕ
ABOUT 4"
EXISTING WALL
SECTION A-A



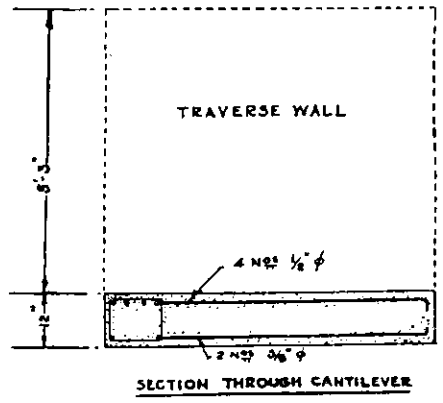
DETAIL OF R.C.C. BEAM SUPPORTING FRONT WALL (CLEAR SPAN 12)



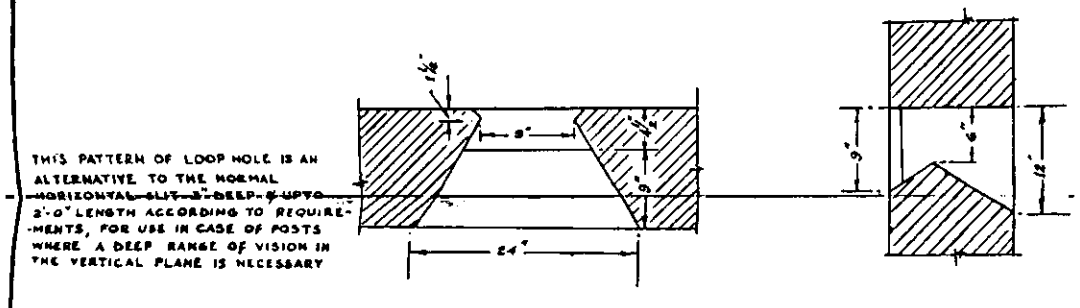
PLANS OF ALTERNATE BRICK COURSES



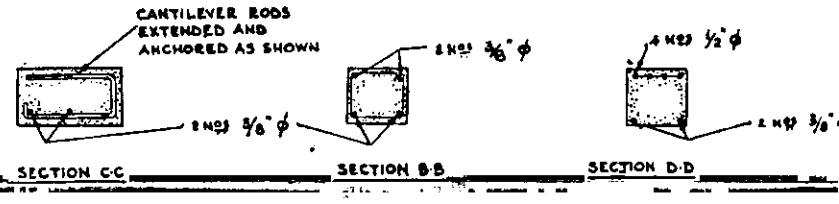
PLAN OF R.C.C CANTILEVER (TOP RODS ONLY SHOWN)



SECTION THROUGH CANTILEVER


THIS PATTERN OF LOOP HOLE IS AN ALTERNATIVE TO THE NORMAL HORIZONTAL SLIT 3" DEEP ϕ UPTO 2'-0" LENGTH ACCORDING TO REQUIREMENTS, FOR USE IN CASE OF POSTS WHERE A DEEP RANGE OF VISION IN THE VERTICAL PLANE IS NECESSARY
24"
HORIZONTAL SECTION
VERTICAL SECTION

DETAIL OF LOOP HOLE



NOTE:-
THE LOAD IS CARRIED BY THE MAIN WALLS. THE DESIGN IS SUITABLE FOR USE ON TERRACED ROOF TOP WHERE THE ROOF SLAB IS NOT STRONG ENOUGH TO WITHSTAND THE LOAD OF A MONOLITHIC STRUCTURE.

DESIGN FOR A FIRE-WATCH POST ON TOP OF TERRACED ROOF

SCALE: 1½ = 1' & 1" = 1'

DRG. NO. C.A 4

CHIEF ADVISER, FAC

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GOVERNMENT OF INDIA

DEPARTMENT OF LABOUR

NOTES ON A. R. P. PLANNING AND CONSTRUCTION FOR NEW FACTORIES OR EXTENSIONS

SUPPLEMENTARY TO "A SUMMARY OF AIR RAID PRECAUTIONS APPLIED TO FACTORIES".

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20th April 1942.

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Notes on A. R. P. Planning and Construction for New Factories or Extensions.

I. General.

1. The following notes give a brief general outline of the nature and principles of the Air Raid Precautions measures it is desirable to incorporate in the planning and construction of new factories or extensions in time of War. They do not attempt to cover the detailed design of structures to resist the effects of bombardment; for this reference must be made to other literature. The application of the general principles to the problems of each Factory is a matter for careful individual study and involves the taking into account of the many variable factors. The same general principles apply to existing factories, but it is naturally more difficult to carry them out economically without undue interruption to production.

2. The object of A. R. P. planning and construction in a vital factory is to provide, within the limits of economy and practicability, the maximum degree of protection for personnel against air attack, and also to insure against interruption or delay to vital production owing to air raid damage. The former consideration will require the provision of shelters, facilities for First Aid, Control Centres and other A. R. P. Posts, means of receiving and communicating warnings, adequate telephone communication; and also structural measures of protection, removal of glass, etc. The latter consideration will dictate the provision of alternative sources of power, the protection of vital plant (including the design of structures to resist spreading collapse, the individual protection of particularly vital plant, the general protection of plant by means of protective walls, etc.), the incorporation of adequate and satisfactory measures to prevent the outbreak and limit the spread of fire and to assist in fighting it when it does occur.

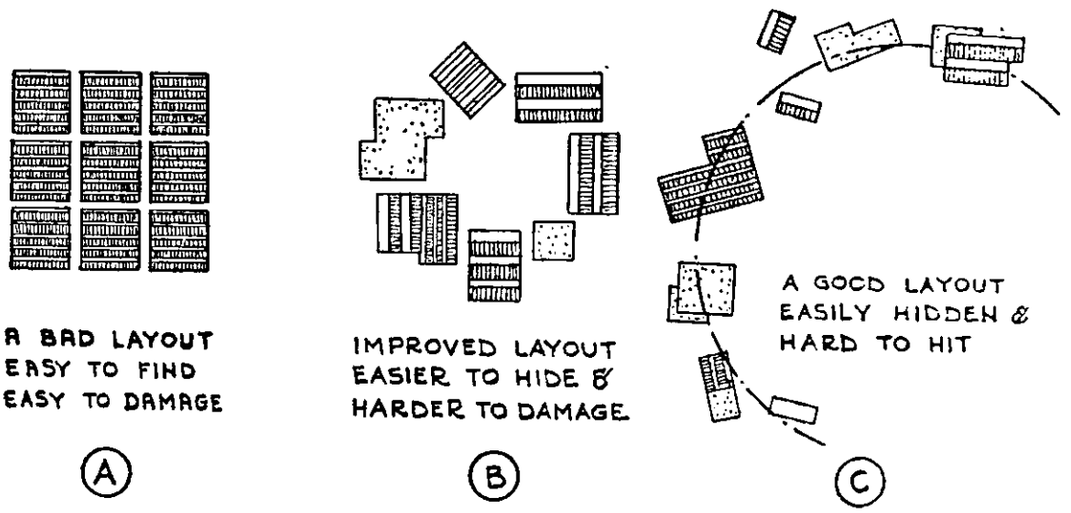
3. A. R. P. planning is inseparable from the planning and siting of the factory as a whole. It should be fully considered and the Chief Adviser, Factory A. R. P., Deptt. of Labour, New Delhi, consulted, while plans are still on the drawing board, and it should, at all stages of construction, be intimately related to the lay-out of production processes. The resulting construction will be more efficient and economical than if an attempt were made to add A. R. P. measures later as an after-thought.

4. A. R. P. measures must not unduly impair efficiency in production. The designer will have to balance the requirements of production and protection. Where applicable the post-War use of the Factory should be given consideration, but it should not be allowed to override War-time requirements such as economy in materials and labour, speed of erection or the selection of a roof-design which is not liable to spreading collapse.

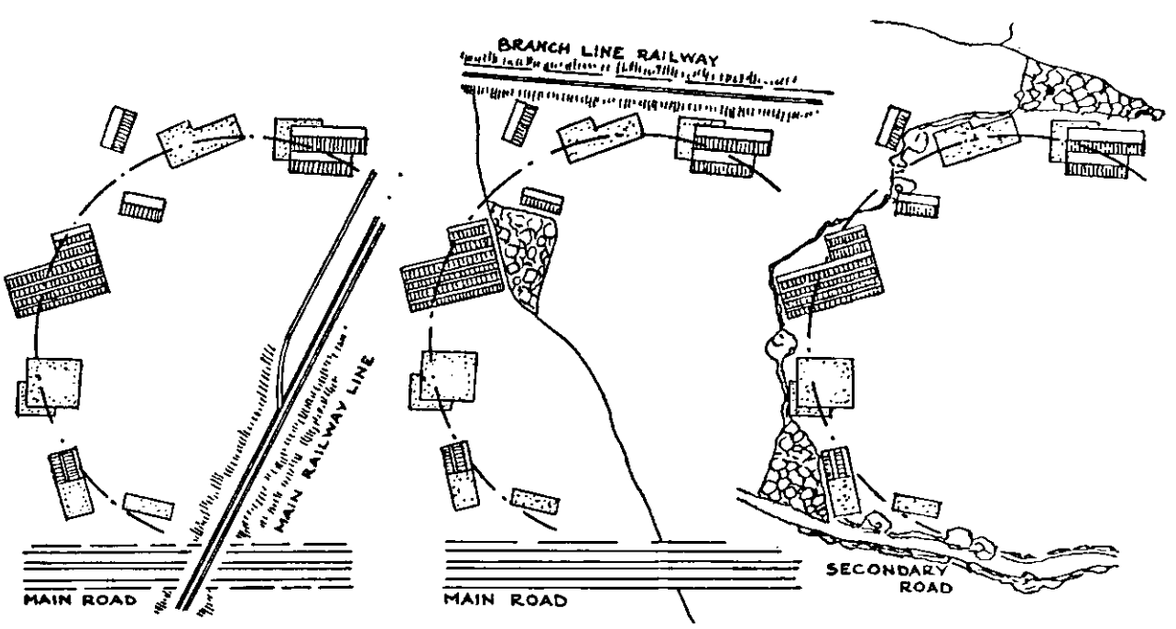
5. Satisfactory A. R. P. construction and planning is of itself of no avail in the absence of thorough and efficient A. R. P. organizations, training and equipment. These are outside the scope of the present notes; a reference may be made to Chapter 8 of "A Summary of A. R. P. Applied to Factories", and any supplementary instructions which may be issued.

II. Siting & Layout.

1. As far as possible proximity to conspicuous landmarks including other factories or buildings of outstanding air visibility, reservoirs, waterways etc. should be avoided; where it is possible to find a site possessing natural features, such as trees, hedges and woods, this is of great advantage. Such natural features should be retained wherever feasible and worked into the factory plan.



COMPARATIVE LAYOUTS FOR FACTORIES



COMPARATIVE SITES FOR FACTORIES

2. In the general layout the creation of an easily recognised target, *e.g.*, by symmetrical planning or by laying out a regular framework of roads, should be avoided. Buildings should be placed as far as possible in a single file, on the line of a curve such that the "centre of gravity" of no three buildings lies on a straight line. Parallelism between buildings must be avoided, and regularity or symmetrical planning should not be attempted. (*See* drawing on page 2.)

3. The area of service roadways should be kept to a minimum and they should not be too close to the buildings so as to outline them, but should lie some distance away, only approaching for purposes of service, and then at as few points as possible.

4. The factory should be split up into separate buildings as far as efficiency permits. The buildings themselves should not exceed about 200 ft. in length or width, or 40,000 square feet in floor area, except where greater dimensions are essential to the process. Buildings should be spaced as widely apart as possible; 50 ft. is a minimum, and 100 ft. or over is very desirable.

5. Throughout the planning of the factory the principles of dispersal and duplication should be applied to the fullest practicable extent. Means of road access, as well as public services, should be duplicated to minimize dislocation of communications through bomb damage etc.

6. As regards production processes, the principle is that no vital process should be subject to complete interruption as a result of any one bomb. Several machines performing the same process should not be grouped together, so as to be vulnerable to a single bomb, but should be dispersed. The principle is that should the chain of processes be interrupted by damage in one part of the Factory, an alternative series of machines performing the same chain of processes should be available elsewhere in the Works.

III. Methods of Structural Protection

1. *Structural Protection against Fire.*—Fire has undoubtedly caused far more damage than all other forms of destruction put together. When unchecked, fire almost always ends in the complete gutting and eventual collapse of the building involved; and it is liable also to spread to neighbouring buildings by means of radiant heat or actual burning fragments. A fire acts as a beacon lighting up the area, and consequently attracts the attention of other bombers laden with H. E.

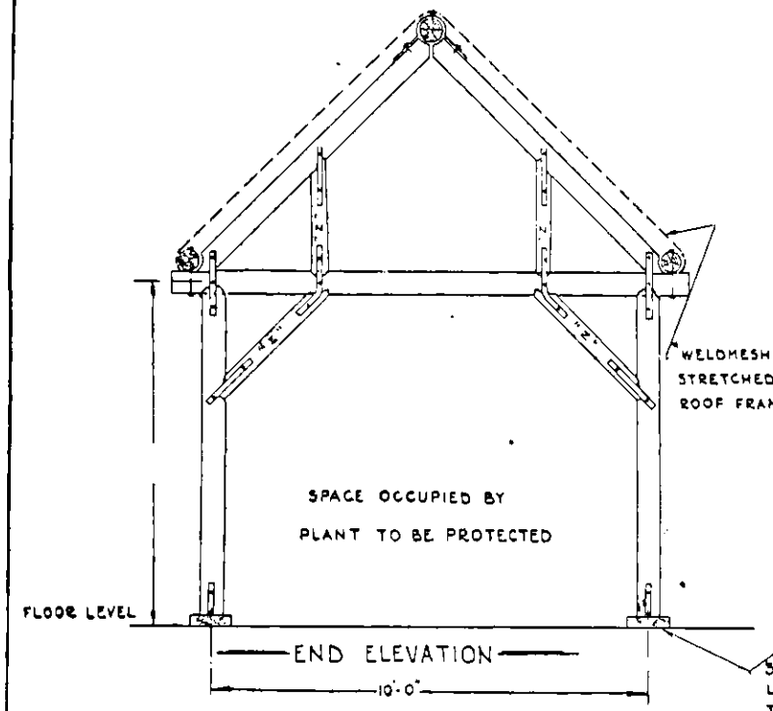
In avoiding, preventing and checking fires, factory discipline, the organisation of effective personnel services, and the provision of adequate water supply are of the highest importance. Structural measures are also however necessary. These should include:

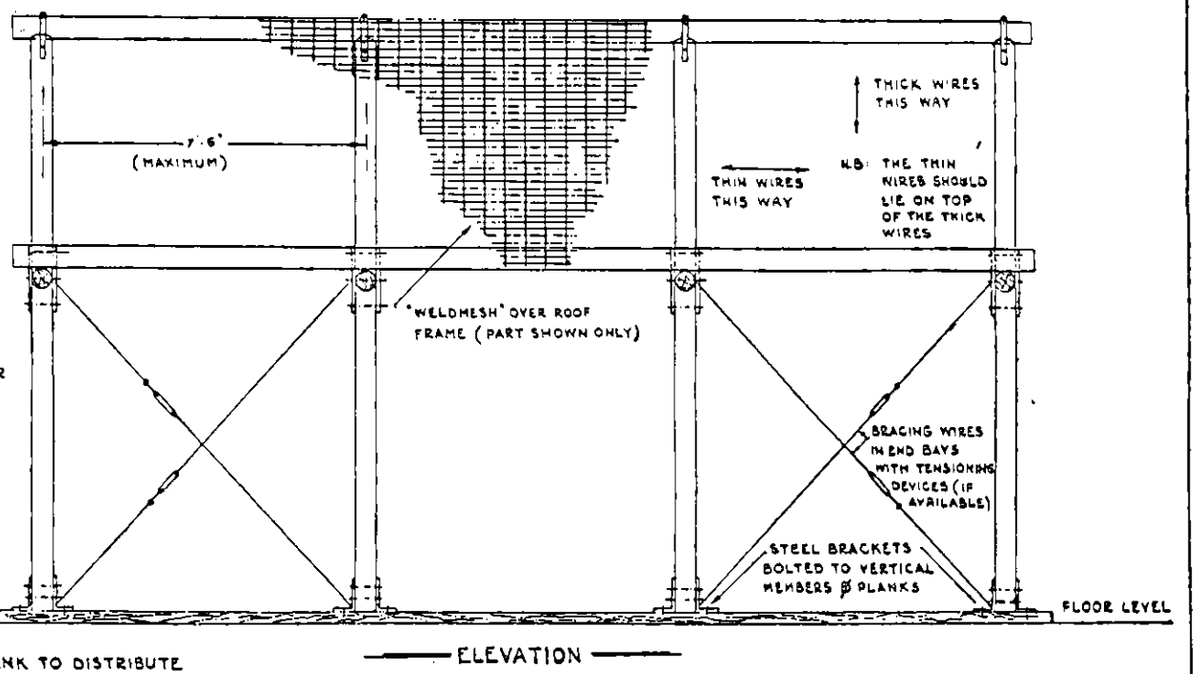
(a) The avoidance of combustible material in all construction, particularly in roofs.

(b) The dispersal and protection of inflammable or combustible stores.

(c) The limitation of the size of undivided compartments to 20,000 sq. ft. In building dividing walls as fire-stops, the dangers of collapse and disintegration must be taken into account.

(d) For buildings where highly combustible materials are likely to be stored or handled in considerable quantities, a structural design should be prepared which affords reasonable protection against the penetration of light incendiary bombs, and which will have adequate resistance to the effects of any fire which may take place inside the building. Subdivision into compartments of not more than 10,000 sq. ft., preferably less, should be arranged.




7'-6" (MAXIMUM)
THICK WIRES THIS WAY
THIN WIRES THIS WAY
N.B: THE THIN WIRES SHOULD LIE ON TOP OF THE THICK WIRES
"WELDMESH" OVER ROOF FRAME (PART SHOWN ONLY)
BRACING WIRES IN END BAYS WITH TENSIONING DEVICES (IF AVAILABLE)
STEEL BRACKETS BOLTED TO VERTICAL MEMBERS & PLANKS
FLOOR LEVEL
ELEVATION

3" PLANK TO DISTRIBUTE LOAD ON FLOOR & TO TIE THE VERTICAL MEMBERS TOGETHER

NOTES :-

1. THE FRAMEWORK SHOULD CONSIST OF TIMBER POLES OR BALLAHS 5" TO 6" IN DIA: WELL FASTENED TOGETHER. MEMBERS MARKED "Z" CAN BE SLIGHTLY SMALLER. SPLICES SHOULD BE AVOIDED IF POSSIBLE.
2. THE DIMENSIONS WILL OF COURSE DEPEND ON THE SIZE & SHAPE OF THE MACHINE TO BE PROTECTED BUT THE PANEL SPACING SHOULD NOT EXCEED 7'-6". THE DESIGN SHOWN IS OF A TYPE CONSIDERED SUITABLE FOR THE PROTECTION OF A TURBO-ALTERNATOR SET.
3. ALL WOODWORK TO BE PAINTED WITH A FIRE RETARDANT PAINT
4. THE FRAME IN MANY CASES HAVE TO STAND ON A RELATIVELY LIGHT STEEL FLOOR SURROUNDING THE MACHINE FOUNDATION IT MUST BE ACCEPTED THAT THIS FLOOR MAY BUCKLE WHEN THE FRAME HAS TO WITHSTAND A HEAVY FALL OF DEBRIS SOME PROPPING OF THE FLOOR MAY THEREFORE BE NECESSARY.
5. WELDMESH TO HAVE WIRES OF NO 5 & NO 10 GAUGE WITH APERTURES 3"x1". STANDARD WIDTH OF ROLL IS 7'-0" & THE OVERLAP SHOULD BE ABOUT 6". WELDMESH IN THIS SIZE WEIGHS ABOUT 1 LB PER SQUARE FOOT.

TRACED FROM ELECTRICAL COMMISIONER'S DRG NO ELC 508

DESIGN FOR A TIMBER FRAMEWORK WITH WELDMESH PROTECTIVE SCREEN TO RESIST FALL OF DEBRIS.

SCALE :- NOT TO SCALE

DRG. NO 3

CHIEF ADVISER FACTORY A.R.P

2. *Structural Protection against High Explosives.*—The standard of protection laid down, *viz.* 13½″ brickwork laterally and 4″ to 6″ of reinforced concrete (according to the quality of the concrete) overhead or their equivalents, was intended to give protection against blast and splinters from a 500 lb. H. E. bomb exploding not less than 50 ft. away, and from A.A. fragments, light debris, and light incendiary bombs. Results have shown that structures conforming to these standards do actually afford protection within the limits intended.

When a shed gets a direct hit, the major part of the damage is caused by bomb fragments, crater debris, and machinery or tools flung violently about by the explosion. Protective walls should be planned to divide the floor area into small compartments. The walls should be carried to not less than the height of vulnerable important plant, and must be strong and stable, built with buttresses or return walls where possible.

Overhead protection is a rather more difficult problem. If penetration by light incendiary bombs or falling fragments from A.A. shells is to be avoided, then it is necessary to provide a reinforced concrete slab at least 4″ thick or its equivalent, but the weight of this construction results in comparatively heavy construction beneath. For this reason such a protective roof is not suggested for all buildings, but it is necessary where the factory or part of the factory contains delicate plant likely to suffer much damage from falling fragments.

Heavy machinery is not likely to suffer much and it would be sufficient to provide local protection to individual machines and to vital parts of individual machines rather than to incur the cost of providing full protective walling round the whole building.

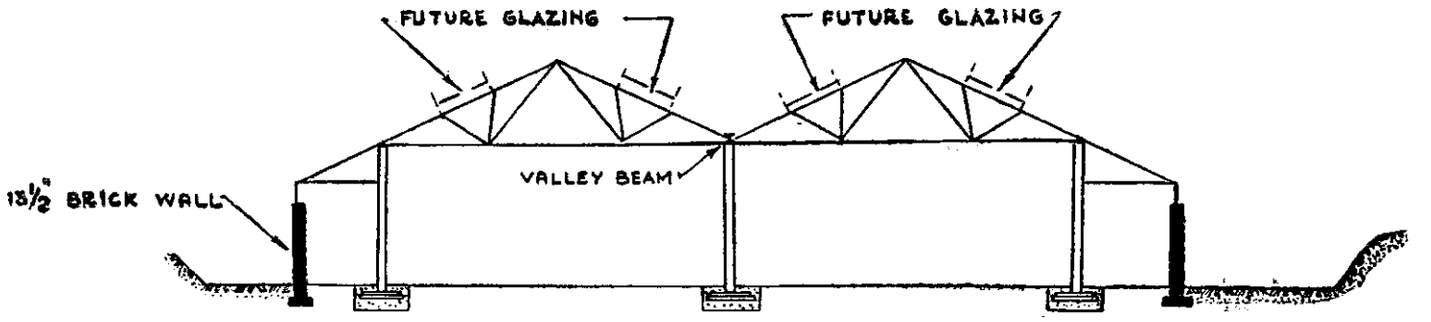
For vital plant and machinery, as well as large motors, rotary converters, switch gear, etc., overhead protection against falling debris may be provided by erecting a timber framework over the machine or plant with a weldmesh protective screen. (See drawing on page 4.)

It is not practicable to provide a structure resistant to a direct hit by a H. E. bomb, but it is essential to minimize the damage as far as is economically possible. Certain common structural types have the serious disadvantage that they are liable to progressive failure. When a main member is cut, the roof trusses supported by it fall, and in doing so bring about the collapse of the adjacent main member with the roof it supported and so on. Such types of structures should be avoided.

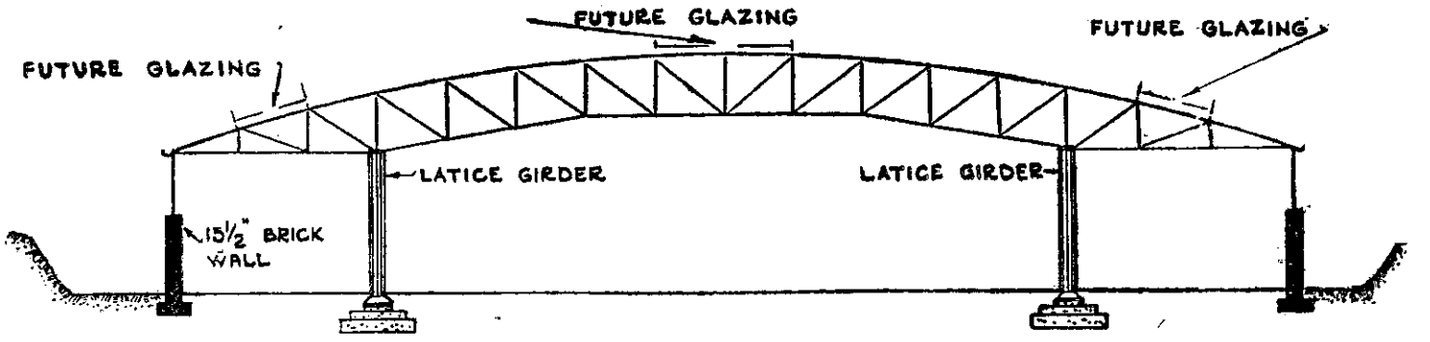
IV—Construction of Buildings.

1. *Framed Construction.*—All buildings, whether of one or more storeys, should be fully framed. The only exceptions, *on merits*, to this rule are cheap and unimportant temporary buildings where collapse is of no consequence, and light buildings containing explosives which are intended to disintegrate in the event of an explosion. Buildings with beams supported partly on columns and partly on load-bearing walls, are not framed structures, though occasionally so described. They have been shewn to be highly vulnerable.

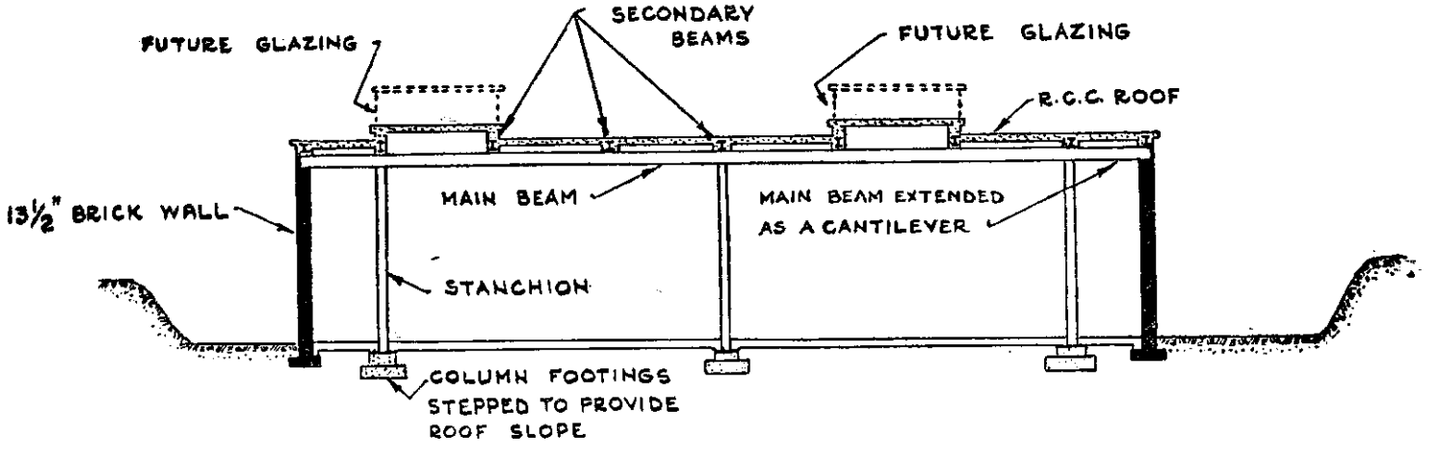
2. *Structural Continuity.*—The frame, whether of steelwork or reinforced concrete, should be specially designed to develop as much structural continuity as possible, to avoid the danger of progressive collapse resulting from the destruction or collapse of any one member (*e.g.*, the displacement of a stanchion base) by a direct hit. Reference should be made to Chapters 2 to 6 of "A Summary of A. R. P. Applied to Factories" for a general discussion of the problem and typical details. This involves very little additional expense if the framework is designed on this principle from the beginning. Certain types of roof truss, *e.g.*, the cantilever "umbrella" or "apex lattice girder" type, are inherently more resistant to spreading collapse than others, *e.g.*, the simply supported "northlight" truss. The methods of strengthening include, as may be appropriate, making a rigid



CROSS SECTION



CROSS SECTION



CROSS SECTION

TYPICAL CROSS-SECTIONS SHOWING EXTERNAL WALLS INDEPENDENT OF MAIN STRUCTURE

joint between trusses and stanchion caps, making valley beams, etc., continuous over stanchion caps, providing adequate rafter bracing, introducing "redundant" members as additional connection between adjacent trusses, anchoring down the free ends of cantilever trusses, etc.

The importance of such measures must be stressed. Instances of complete collapse of a whole roof have not been infrequent, and it is of small use to protect the vital plant and machinery if the roof collapses on it.

3. *Walls.* (a) *External Walls.*—In a well-designed war factory the roof is carried independently of the walls (See drawing on page 6), and the function of external walls is limited to the exclusion of the weather, the prevention of escape of light at night and the provision of lateral protection against blast, splinters, etc. The last consideration is essential for the protection of personnel, plant, tools and in some cases delicate and valuable finished or semi-finished products. Consequently all Factory buildings, except buildings which are purposely made light because they contain explosives and perhaps also sheds containing non-vulnerable stores where few men are employed, should where possible have external walls of protective construction. Unless there are high buildings in the vicinity which might detonate bombs above ground level, such protective construction need not, and should not, be higher than the height of a man or vulnerable vital plant whichever be the greater. Doors and other openings below that level should where possible be baffled or alternatively masked by other buildings of substantial construction. Doors of adjoining buildings should at least be staggered, rather than "straight through".

External walls should be structurally independent of the framework of the building: *e.g.*, they should not be in the same line as the stanchions; alternatively, the walls may butt up against cased stanchions with a straight joint lined with building paper.

The upper part of the wall should be light framing covered with brittle sheeting such as corrugated asbestos. Corrugated iron is not recommended for this purpose, since if subjected to blast pressure it may distort the steel framework before it fails itself.

(b) *Internal Walls and Partitions.*—Internal walls are not required to exclude the weather or to prevent escape of light, but they have a variety of other functions such as to isolate departments requiring temperature control, to limit dust, noise, etc., to act as fire-stops, and to enclose stores and offices. One of their most important functions is to provide lateral protection for plant and personnel.

Protected stores for delicate tools, gauges and jigs, or protected enclosures for particularly important plant, should be utilised wherever possible to afford general lateral protection to production machinery. In some large shops internal shelters close to places of work may also be necessary and can perform the same function. Internal protective walls should also be provided as required for the specific purpose of protecting production machinery. In the initial layout of workshops the necessity for internal lateral protection for plant and personnel should be recognised from the outset, and enough space should be provided for the necessary protective structures to be incorporated as detailed planning proceeds.

Internal partitions, etc., required for other purposes than protection should not be of such a character that they can themselves be a source of danger by disintegrating and forming missiles through a near-miss. In practice this means that they must be of the lightest possible construction, *e.g.*, plaster-boards on light framework, unless they are to be of protective construction. It is most important that walls not of protective construction should be omitted except where absolutely indispensable.

4. *Roofs.*—(a) The selection of the material for the roof covering will to a large extent determine the design of the structural framework and of the workshop generally. The shape, however, of the roof is also of importance. North-light roofs lose their special value in war-time owing

to the practical objections to roof-glazing; and from the point of view of camouflage they present serious difficulties, as the sharp lines of shadow cannot be painted out: Flat roofs, curved roofs and pitched roofs of low angle are to be preferred in that order.

(b) Especially where high fire risks are involved, the possibility of a reinforced concrete roof should be considered on account of its resistance to incendiary bombs.

(c) Roof sheeting is not so vulnerable to blast from near misses as wall-sheeting; but it is liable to be lifted off by blast from a direct hit. The best form of sheeting for general use is undoubtedly corrugated iron. With the usual spacing of hook-bolts, these will usually fail before the steel purlins, etc., so that the sheeting blows off without disturbing the frame-work.

(d) Corrugated asbestos breaks up over a wider area and so there is less danger of straining the steel work. The fragments however may form dangerous debris.

(e) If insulating boarding is essential to the process, it should be placed immediately under the sheeting and above the purlins. Otherwise it will impart greater resistance to the roof covering, which will distort the steel-work badly under blast.

(f) Roof lights should ordinarily be omitted entirely, but the frame-work for roof-lights which may be required after the war can be formed during construction and sheeted over.

5. *Glazing.*—The exigencies of obscuration and the risks to personnel and delicate plant from flying glass make it necessary to limit glazing and to omit roof lights in new construction. Wall lights may be provided in the upper parts of external walls. They should be covered with a flexible glass substitute. If glass must be used it must be protected, but glazing must never be used in the vicinity of delicate plant and machinery such as rotary convertors, motors, etc.

Effective obscuration devices must be provided; these should be rendered non-inflammable if possible.

Additional lights which may be required in peace time can be provided for by forming the openings during construction and building them up or covering them over.

6. *Artificial Lighting and Ventilation.*—Blackout conditions together with the elimination of glazing and prolonged working hours including the necessity for working night shifts, make it essential to adopt from the first a good standard of artificial lighting and ventilation. The scheming of artificial lighting to provide satisfactory levels of illumination is a matter of scientific planning, and technical advice should be sought before adopting any particular scheme.

In order to ensure the safe and rapid evacuation of personnel to shelters, and to assist movement after the general interior lighting has been extinguished, sufficient pilot lighting should be provided to distinguish gangways, passages, stairs and dangerous obstacles. Expensive system employing standby batteries are not as a rule necessary; the requirements can be fully satisfied by the provision of 15 or 25 watt lamps in deep opaque reflectors with a cut-off well below the horizontal, mounted about 10′ above the floor and spaced 50′ to 100′ apart along lines of gangways, and in general along interior evacuation routes. These lamps should be on a special circuit, by-passing the main switches which control the normal works lighting system, to ensure that they remain in operation after the main works lighting has been extinguished. The pilot lighting should be in operation continuously or switched on immediately on receipt of the "Alert".

7. *Protection of Vital Plant.*—The questions of what is and what is not vital plant and of the best and most economical layout of protection walls, etc., are matters for careful individual consideration at each factory. The general principles are set out in Part III of these notes, and chapter of "A summary of Air Raid Precautions Applied to Factories".

V.—Services.

(1) *Electric Supply.*—Essential electric power supplies should, where practicable, be duplicated to 100 per cent. of the required capacity from alternative sources of supply. Most of the important factories will have their own generating stations, and an alternative source of supply should be arranged by obtaining bulk supply from a public electric supply company where this is possible. In some factories the lack of a convenient alternative source from a public supply may make it necessary to instal standby generating plant of sufficient capacity to operate vital electrical appliances. The electric supply cables should be brought into the factory along different routes; and should enter at widely separated points through different sub-stations. The internal supply to the factory should be by means of a ring main, so that the supply cannot be interrupted by any one bomb. If possible all important shops should be supplied from two alternative sub-stations.

Consideration should also be given to the possibility of interconnection with the electric supply of a neighbouring factory as a standby for both plants.

The Electrical Commissioner to the Government of India should be consulted before the final selection of the site, to ensure that ample sources of supply are available.

2. *Gas Supplies.*—In India gas supplies for process work will usually be supplied from the companies' own generating plant and they will, therefore, have to rely entirely on their own resources for dealing with damage to the plant. Where the gas is necessary for important processes an obvious protection is to provide a duplicate standby plant located at some considerable distance from the other plants. To reduce to a minimum the period for which the plant may be shut down for want of gas, should the gas main be damaged, repair squads of trained men, fully equipped with made up lengths of pipe and all the necessary equipment for its rapid installation, should be maintained in the factory.

Where the main gas supply is provided from a number of generators instead of from one large unit, the generators should be dispersed as far as possible.

3. *Water Supplies for Processes.*—Where water supplies are essential for processes it may be necessary to arrange for alternative supplies, which are most conveniently provided by means of reserve tanks or reservoirs. In many cases the supplementary water supplies for fire-fighting will be suitable also for processes and the two problems need not be considered separately. In other cases—where for instance sea water or canal water is used for fire fighting—a separate supply of water for processes may be needed.

4. *Dangerous Mains, etc.*—Dangerous service mains in buildings, such as gas, steam and high pressure water, should have readily accessible control points where they can be rapidly cut off in case of need.

5. *Water Supplies for Fire Fighting.*—For fire fighting purposes piped water supplies and hydrant systems should not be relied upon. An ample supply of fully equipped trailer pumps and static water tanks located in strategic positions should be installed. Static water tanks should not be less than 10 to 15 thousand gallons capacity, and where 500 gallon trailer pumps are prescribed, may with advantage be double this size. Over and above the general provision of static water tanks for dealing with the factory as a whole, separate tanks should be provided in suitable locations in the vicinity of all buildings or store yards containing highly inflammable materials.

6. *Telephones.*—A duplicate external telephone line, independent of the factory switchboard, should be installed in the Factory Control Post, which should also be connected to the main external telephone system by a separate line by-passing the main switchboard.

The Factory Control Post should also be connected to whatever system is in operation for communicating the "Warning".

The Control Post should also be connected telephonically to all Posts housing A. R. P. Services, and to groups of shelters in special cases.

VI.—Special A. R. P. Structures.

1. *Shelters.*—(a) Standard of design and spacing of shelters are given in Chapter 11 of "A Summary of A. R. P. Applied to Factories". The principles therein should not be departed from without the approval of the Chief Adviser, Factory A. R. P.

(b) Shelters should be as close as possible to places of work. It must be possible for personnel to occupy them within 1 to 3½ minutes at the outside. In siting shelters local risks must be taken into account, *e.g.*, they should not be in the vicinity of inflammable liquids or dangerous chemicals, and underground shelters should not be close to and below the level of water-tanks of large capacity, steam-, water- and gas-pipes, etc., should not run through shelters.

(c) Shelters for personnel generally should normally be provided in the form of slit trenches of the types illustrated in "A Summary of Air Raid Precautions Applied to Factories" (in special cases where appropriate sites for slit trenches are not available sufficiently close to places of work, in the form of fully protected shelters along the walls of or even occasionally inside buildings).

Slit trenches must not be erected close to buildings; they must be at least half the height of the building away. Where this distance cannot be maintained fully protected shelters must be provided (Type D).

Shelters or Posts should be provided for A. R. P. personnel (except for shelter wardens and others who must be in the trenches.)

In cases where shelters have to be provided inside or adjoining buildings, the roofs or ceilings of the shelters must be designed or strengthened to withstand the possible debris loads. Fully framed buildings are preferable for this purpose. Reliable means of emergency escape to the open air, in case of collapse of the building, must be provided.

The normal standards of protection for fully protected shelters are illustrated in Type D (wall shelter) appended to Chapter 11 of "A Summary of A. R. P. Applied to Factories"; this must be adapted to meet the requirements of independent shelters.

Fire Watcher Posts and Keymen Posts should have observation loop holes. These are also often valuable for Wardens' Posts, etc.

The normal type of observation loop hole is a slit 3″ deep and upto 2′ wide, 5′—6″ above the floor—in special cases where a wide range of view is required in the vertical plane, as in some Fire Watchers' Posts, loop holes as shown in the design for a Roof Fire Watchers' Post (Drawing No. C. A. 4 issued separately to all factories) should be used.

(d) *External Pilot Lighting.*—External evacuation routes should where necessary be lighted by either of the following methods:—

(i) *Shielded Hurricane Lamps.*—Hurricane lamps shielded so that the candle-power does not exceed 1·0 and no light is thrown either above the horizontal or on to the ground, may be spaced out to mark the edges of routes, obstructions, and intersections. They should be alight from dusk to dawn. Economy can be effected by disposing the lamps on alternate sides of the pathway ("staggered spacing").

(ii) *Pilot (Marker) Lights.*—Pilot (Marker) lights, may be mounted at a height of between 3 feet and 6 feet along the edge of the route. The distance between fittings should not exceed 150 feet, and "staggered spacing" should be employed.

(iii) *White Guide Lines and Markings.*—An extensive use of white guide lines and markings will greatly facilitate movement after dark. Where routes are devious a white edging on both sides of the route is advisable. Broken rather than continuous lines should be employed and repainting should be on a regular and frequent basis.

2. *A. R. P. Posts.*—The design of A. R. P. Posts should follow the same principles, with full blast and splinter-proof protection, lateral and overhead. All entrances must be baffled. Seats where provided should be "end on" and not up against walls. Emergency exits should be provided except in the case of very small posts (*e.g.*, for fire-watchers or keymen). Small ventilation appertures should be provided where necessary immediately under the roof.

(a) *Factory Control Post.*—This post, which is the nerve centre, should be large enough for at least 4 or 5 men to work in comfort, with the necessary tables, charts, etc. The number to be accommodated and the size will depend upon the size of the factory. The Post should incorporate or be adjacent to the factory telephone exchange (in any case the exchange must also be fully protected);—otherwise a satellite exchange must be provided in the Control Post. And the Control Post should preferably be incorporated in or adjoin the Administrative Block. Artificial Lighting should be either by means of an independent generator set or by mains lighting on a pilot circuit by-passing the main switch. An emergency battery set should be installed as a standby in case of failure. Local fans should be provided for ventilation. Current for the fans must be maintained during a warning period.

(b) *First Aid Centre.*—This should incorporate the peace-time Factory Surgery or Dispensary, but must be protected. The baffles at the doors must allow passage for stretchers. The Centre should be at ground floor level and must have convenient road access for ambulances.

Lighting and ventilation should be as for the Factory Control Post. A high standard of artifical lighting is required in the First Aid Treatment Room itself.

(c) *Warden's Posts, etc.*—These are smaller protected posts, sited to suit the factory A. R. P. Scheme. Where the provision of a small battery lighting set is not feasible, long-life electric hand-lamps are sufficient for artificial lighting, and fans are not ordinarily necessary.

(d) *Posts for Keymen and Fire-Watchers.*—These should be designed as illustrated in Sheet 6 of "A Summary of A. R. P. Applied to Factories". Observation apertures must be included.

Elevated Fire Watcher Posts should be sited as required on roofs, etc., so that watch may be kept over all roof areas, external fire risks, etc. Quick means of escape must be provided, *e.g.*, by a rope in addition to the normal means of access.

These Fire Watcher Posts, which may be combined Stirrup Pump Party and Fire Watcher Posts (raised where necessary) should be located to keep watch in areas or works buildings containing a specially high fire risk—*e.g.*, stores of combustible articles. The object is to enable incendiary bombs to be put out before they start a conflagration or to enable an outbreak of fire to be dealt with at its inception.

(e) *Fire Stations and Trailer Pump Houses.*—These buildings should be fully protected and suitably dispersed to cover as much of the Factory as possible. They should be located close to principal static water supplies and should have convenient road access. The entrance must be effectively baffled by traverse walls, unless the House is sited facing and close to a building of substantial construction. They must be large enough to accommodate the pump crews.

(f) *Ambulance Houses.*—These also must be protected. The same conditions as regards road access, protection of entrances, etc., apply to Fire Stations.

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